U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

AD-A033 812

THE ACQUISITION OF SONOBUOYS FOR THE U.S. NAVY

DEFENSE SYSTEMS MANAGEMENT SCHOOL
FORT BELVOIR, VIRGINIA

MAY 1976

DEFENSE SYSTEMS MANAGEMENT SCHOOL

PROGRAM MANAGEMENT COURSE

INDIVIDUAL STUDY PROGRAM

THE ACQUISITION OF SONOBUOYS
FOR THE U.S. NAVY
STUDY PROJECT REPORT
PMC 76-1

[illegible]
COMMANDER, U.S. NAVY

FORT BELVOIR, VIRGINIA 22060

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

THE ACQUISITION OF SONOBUOYS FOR THE US NAVY

5. TYPE OF REPORT & PERIOD COVERED

Study Project Report 76-1

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

James E. Sheehan

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS

DEFENSE SYSTEMS MANAGEMENT COLLEGE
FT. BELVOIR, VA 22060

10. PROGRAM ELEMENT, PROJECT, TASK & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

DEFENSE SYSTEMS MANAGEMENT COLLEGE
FT. BELVOIR, VA 22060

12. REPORT DATE

76-1

13. NUMBER OF PAGES

25

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)

UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: THE ACQUISITION OF SONOBUOYS FOR THE U.S. NAVY

STUDY PROJECT GOALS:

1. To review and evaluate procedures utilized in the procurement of sonobuoys, with particular emplasis on Test and Evaluation.
2. To put into prospective those aspects of weapon systems acquisition that apply to non major weapon systems.

STUDY REPORT ABSTRACT:

This study focuses on the historical growth and present application of procurement practices for the acquisition of sonobuoys for the U.S. Navy. An historical approach was utilized to develop the setting for present conditions, to illuminate the effect of technology growth on the process. This is especially noteworthy in the 1960's. Particular emphasis was devoted to the area of test and evaluation. Testing of these expendible units is devoted primarily to the area of production units since the nature of the sonobuoy production cycle includes the production of hundreds of thousands of units following the initial production go ahead. Rationale is provided for the present procurement concept, Firm Fixed Price contract type and specific reviews, audits and tests. Recommendations as to areas warranting further study are listed.

KEY WORDS

MATERIEL   ACQUISITION   SENSORS   BUOYS   ANTISUBMARINE WARFARE

KEY WORDS: SONOBUOY ACQUISITION
SONOBUOY PROCUREMENT

NAME, RANK, SERVICE	CLASS	DATE
James E. Sheehan, CDR USN	PMC 76-1	May 16, 1976

THE ACQUISITION OF SONOBUOYS FOR THE U.S. NAVY

STUDY PROJECT REPORT

INDIVIDUAL STUDY PROGRAM

Defense Systems Management School

Program Management Course

Class 76-1

by

James E. Sheehan

Commander, U.S. Navy

May, 1976

Study Project Advisor

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This study project represents the views, conclusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management School or the Department of Defense.

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EXECUTIVE SUMMARY

The purpose of this study was to provide information on the historical and present approach to the total acquisition cycle of sonobuoys for the U.S. Navy. A sonobuoy, which is an expendable sensor used by aircraft in the prosecution of anti-submarine warfare, is a relatively complex, densly packaged and rugged piece of avionics equipment. The sonobuoy is used in conjunction with airborne processing equipment to convert underwater submarine sound signals into discernable information which identify and locate the target.

Sonobuoy production has grown significantly from its initial in-house efforts of World War II. All production is now accomplished by contracting firms, as is the majority of research and development.

As the technology increased, particularly in the 1960's, so too did the testing requirements. New, elaborate testing facilities have been designed and established in Maine and the Virgin Islands. Extensive testing, particularly on production end items is accomplished to ensure agreement with specifications and to verify reliability.

Although the requirements for sonobuoy functional characteristics are normally developed in response to processor requirements, provisions are provided for operational requirements from fleet users. These requirements and changes however, are normally minor in that the end product must be fully compatible with existing processors. In general, when functional changes to existing processors or new processing equipment is specified, they are designed such that sonobuoys presently existing in the fleet inventory remain compatible and do not become immediately obsolete, thus minimizing logistic and operational costs.

Several areas for further research are detailed in this study, namely: operational requirements, failure data collection, stowage and handling, mobilization base requirements, sample and lot size determination, and classification of failures from an operational viewpoint.

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SECTION I

BACKGROUND

"Where once the submarine was a weapon employed solely against other Naval forces, in recent times this system has employed both strategic and tactical missle systems capable of striking deep within an enemy's land masses." And as the full potential of the submarines' capabilities are being realized, so too has the importance grown, in the efforts to neutralize this threat.[1]

Anti-submarine warfare (ASW) may take on many forms, from the static to the highly dynamic. Where once underwater obsticles, mines and torpedoes could lie and wait for the transiting enemy in relatively restricted waters, enemy submarines are now found primarily in the unrestricted open seas.

Perhaps the most dynamic and most time-sensitive mode of ASW is the utilization of the aircraft as the primary element of detection, classification, tracking and destruction of the enemy submarine. The only ASW system that has a definite speed advantage over the submerged submarine is the aircraft. Additionally, the aircraft has the added advantage of being covert and undetectable to the submarine since the two operate in different mediums.

For all practical purposes the submarines cannot detect or identify a persuing aircraft. It's only defense against the aircraft lies in its attempt to remain undetected.

To bridge the barrier between the sea and the air in favor of the aircraft is the sonobuoy system, which gives the aircraft the ability to acoustically listen to underwater sounds. These sounds are timed,

NOTE: This notation will be used throughout the report for sources of quotations and major references. References are found in the Section titled NOTES.

analyzed and geographically plotted to initially detect and classify and eventually to position and track the underwater target. Although the main elements of this elecro-acoustic system remain in the aircraft, the focal point of the system, the device that enables the bridging of the sea/air interface, is the expendable sonobuoy itself.

Although sonobuoys were invented and used during World War II, they emerged from this war as an unproven component, for they did not aid in the destruction of a single ship.[2] And since actual submarine warfare has not occured since that war the sonobuoy, although in continual use today, has no wartime kill record to enhance its stature.

The technology of electronics and underwater acoustics have advanced significantly during the past three decades and the sonobuoys of today resemble those used during World War II in shape only.[3] A typical present day sonobuoy is depicted in Fig. 1.

The simple sonobuoy consists of a hydrophone, a signal converter and amplifier, a VHF radio transmitter, retarding devices to permit non-destructive aircraft launch and water entry, a battery and flotation equipment.[4] Sonobuoys may be classified by mode, (active or passive), size, function, frequency spectrum, activation time or depth of hydrophone; for purposes of this discussion, however, no distinction will be made as to type or classification since it is not germane to the area in question ie., the term sonobuoy will refer to the device in general, regardless of characteristics.

Immediately following aircraft launch, the rotochute assembly opens (see Fig. 1) to allow the sonobuoy to autorotate slowly and reduce water impact. Upon water entry, the rotochute is jettisoned, the transmitting antenna springs out, the base plate falls free and the hydrophone deploys, an orange-red dye is released and the salt water battery is activated. Most sonobuoys have pre-selected hydrophone depths and activation life settings. After the activation life has expired, a water soluable plug scuttles the entire device. Some sonobuoys have the added feature of remote command scuttling from the aircraft. The sonobuoy then is a paradox;

for even though it is the focus for the confrontation of two multi-million dollar weapon systems, and is the key to success of these two competing technologies, it is a relatively inexpensive and expendable device.[5]

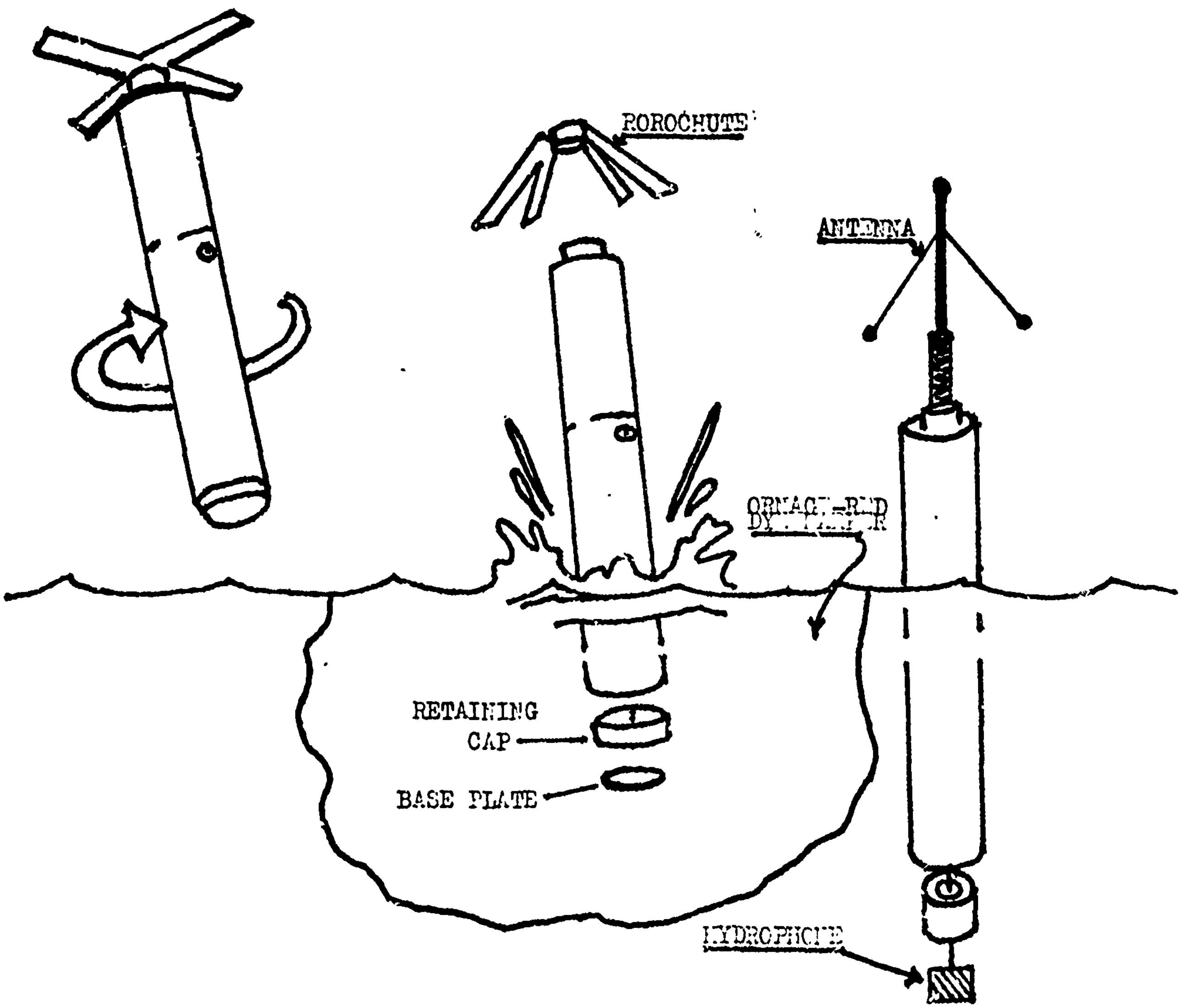

Fig. 1
SONOBUOY DEPLOYMENT

SECTION II

OPERATIONAL REQUIREMENTS

In present day sonobuoy devlopment, the requirement for a specific sonobuoy characteristic is normally a fallout of other development requirements within both Navy and civilian laboratories. Because the sonobuoy is not a fully self contained system, but rather is used in conjunction with the varied processors located in the aircraft, it is normally the design parameter of the acoustic processing equipment that determines the functional characteristic requirements of sonobuoys. The development of the AQA-7 acoustic processing equipment for use in the P-3 aircraft necessitated the requirement for two specific sonobuoy types; namely the SSQ-53 (Directional, Passive) buoy and the SSQ-50 (Command Activated, Active) buoy.[6]

In general each update of acoustic processor retains the capability of utilizing previously acquired sonobuoys, to eliminate operational and logistic problems associated with mis-match of sonobuoy and processor, as well as to reduce costs. This philosophy is continuing into the systems now under development; the AQA-9 processor and SSQ-62 (Command Activated, Active and/or Passive) sonobuoy.

New or revised requirements are also necessitated by the introduction of new aircraft into the inventory as well as by operational necessities. The current Product Improvement Program for sonobuoys is a re-engineering program designed to upgrade certain sonobuoys to better match the increased operating envelopes (altitude and speed) of newer aircraft. This program will additionally improve handling and storage characteristics as well as improved operational capabilities and reliabilities.[7]

Fleet requirements into the sonobuoy acquisition process generally take the form of change requests to existing equipment, such as hydrophone depth and visual aids for location. However, the policy of the Chief of Naval Operations remains, that any fleet activity or Navy Command may submit an operational requirement to the Force and Mission sponsors.[8] Those that are considered valid and worthy of pursuing are then transmitted

to the Chief of Naval Material for development and/or acquisition. In addition to U.S. Navy requirements, all operational requirements and specifications must match those delineated by NATO Committee on Sonobuoy Standards (TRIPARTITE).[9]

SECTION III

PROCUREMENT

A, Background

The initial World War II sonobuoys used by the U.S. Navy were fully developed and produced by the Underwater Sound Labratory at New London, Conn.[10] Following the war, personnel reductions, changing government procurement policies and increasing technology requirements necessitated the gradual introduction of industry into the research and development of sonobuoys. During this post World War II era, the then Bureau of Aeronautics established a comprehensive sonobuoy R&D capability at the Naval Air Development Center (NADC), Warminster, Penna. (This expensive capability still remains at NADC).

During the Korean War, an immediate need was recognized to quickly expand the development and production of reliable and effective sonobuoys. It was at this time that commercial industrial firms became paramount. The transfer of this technology base was effectively coordinated by NADC. The Naval Air Development Center however, maintained it's capability in concept feasibility. Soon a rather broad base of development and production technology, and its accompanying large monetary investments, existed in the civilian industrial complex where it still remains.[11] The most noticalbe producers of sonobuoys for the Navy today are; (alphabetically) Hermes Ltd. of Canada, Magnavox, Sanders Associates and Sparton Electronics.

B. Design Disclosure

During the 1950's and 1960's the Design Disclosure Package Concept for acquisition, which was originated by the Naval Ordnance Labratory for ordnance procurement, was atterpted in the procurement of sonobuoys.

The Design Disclosure Package concept permits complete standardization, unlimited production base, absolute design control including Quality Assurance and eliminates redundant development efforts and costs. This concept however, has drawbacks. It forces responsibility for performance onto the Navy and away from the producer, eliminates competition generated

by contractor value engineering, requires more contracting changes and necessitates a subatantial increase in technically qualified government personnel.[12] The two sonobuoy procurement attempts utilizing the Design Disclosure Package (SSQ-28, and SSQ-42) resulted in failure due to manpower shortages and technical problems.[13]

C. Performance Specification

The most utulized acquisition approach used for sonobuoy acquisition is Performance Specification, in which feasibility investigation is performed by Navy laboratories while the major research and development and all production is performed by industry. The Performance Specification concept encourages lower costs by promoting competition, requires fewer technically qualified government employees, ensures acceptance of performance responsibilities by the contractors, provides fewer contractural problems and has a more rapid acquisition progress. The primary disadvantage of this concept, that it provides no standardized end product, is not considered significant since the sonobuoy, by design, is a non-repairable, non-maintainable, non-reuseable device.[14] Commonality of parts and components is not critical; what is critical is the attairment of the functional and physical specifications. The acceptance of the Performance Specification concept for sonobuoy acquisition has the general consensus of both industry and military personnel and will no doubt continue as the major approach for the forseeable future.

D. Negotiation.

Although Formal Advertising is the desired method for government procurement, procurement may be effected by negotiation if one of 17 specific exemptions apply. These exemptions are detailed in Section III of the Armed Services Procurement Regulation.[15] Production sonobuoys are negotiated under exemption 16 of this Regulation which deals with Industrial Mobilization. To be more specific, the Navy Class Determination and Findings which provides current justification, is quoted in part:[16]

> "1... Sonobuoys are extremely complex, requiring lengthy tooling, and production preparations and their

production delay or disruption would be very detrimental to the Department of Defense posture... It is essential to plan, in the event of conflict short of general war, for dispersed and alternate sources of production to reduce vulnerability and to maximize their chances for survival in the initial stages of a national emergency. Such mobilization planning must retain and foster a production base for an orderly transition from peacetime to wartime conditions....

"5. Use of formal advertising for the procurement described above is not feasible or practicable because the method might require the award of a contract to a low bidder who is not a planned producer under mobilization base planning, thereby preventing the award of single or multiple contracts to sources having the requisite mobilization base capabilities to the detriment of the national defense and mobilization...."

E. Mobilization Base

In general, the mobilization requirements can be separated into two parts; inventory requirements and monthly consumption rates. Inventory requirements are predicated on emergency useage for specified periods. The monthly mobilization consumption, while based upon wartime consumption rates, does not delineate a specific time to deplete stockpiles but requires a plan to expand monthly production to sustain wartime usage. The quantities of sonobuoys, for both catagories are specified by the Chief of Naval Operations. Several problems arise from this concept: Sonobuoys, unlike most other war materials, will quite probably experience a severe increase in usage rate prior to a declaration of war. The quantity specified as inventory requirements must therefore be sufficiently large to permit sufficient production build-up, and world wide delivery. Planning in this area must be accurate and reviewed constantly, for the useage rate of sonobuoys is dependant on such changing factors as; target threat (both quantity and type), environmental water conditions which may or may not be seasonal, geography, specific aircraft mission, tactics employed

and whether the aircraft is operating independantly or in concert with other friendly forces. It is therefore critical that these CNO directed quantities be related to the total mobilization capacity of all producers. It is also ample justification for utilizing exemption 16 to the ASPR for the procurement of sonobuoys.

F. Qualification of Additional Producers

At present, there are two methods for the qualification of additional producers of sonobuoys. Any responsible firm may complete a successful research and development effort through Operational Test and Evaluation. This may result either from a solicited or unsolicited design proposal. Additionally, the Navy will furnish to any interested manufacturer, upon request, a specification, model and drawings for a particular model sonobuoy. This firm may if they desire, and at their own expense, build and submit 50 sonobuoys for testing. If these tests results are favorable, the firm will be added to the list of companies solicited in future procurements.[17]

G. Contract Type

Because of the relatively low technical and cost risks, as well as the high volume of production, FIRM FIXED PRICE (FFP) contracting is utilized for sonobuoy procurement. This contract type, which permits maximum profitability for the contractor, also eases the administration and control requirements for the government. The use of FFP type contracts is also in agreement with the use of the performance specifications concept previously described.

Normally sonobuoy contracts call for a specific number of end items, by type, for each production run. Each production run is broken down into lots, normally of 800, for identification, testing and acceptance. Extensive quality assurance and testing of selected end items is then performed. This will be discussed in greater detail in a succeeding parapraph.

H. Configuration Management

As with most electronic equipments, numerous references, specifications and standards must be utilized to fully and explicitly

describe the product for contracting purposes. Additionally these descriptors ensure that technical performance of the fleet requirements are satisfied. The Naval Air Development Center, under the direction of the Naval Air Systems Command, produced an Aeronautical Requirement (AR) document to ensure sound configuration management of sonobuoys and sonobuoy packaging.[18] This document, which is concise, readable and easily used is applicable to every contract for the procurement of development and production sonobuoys. It ensures that all characteristics of sonobuoys, both functional and physical, are identified and documented; it insures complete control of approved changes to these characteristics; and finally it records and reports to all concerned, the processing and implementation status of all changes.

I. Baselines.

To adequately describe the physical and functional characteristics for the production of sonobuoys, two specific baselines have been established. The first baseline (ALLOCATED) is the exact configuration of the initial units. These are verified by a physical Configuration Audit. This audit, which compares the end item to the required drawings and specification as well as to the particulars of the manufacturing processes employed, is normally accomplished at the contractors facility. In general, the objective of this procedure is to ensure that the first article is in conformance with the requirements previously stated, and to ensure reproducability.

The second (PRODUCT) baseline represents items of the fourth lot of sonobuoys that pass the testing requirements without waiver. This product baseline represents the standards against which all future production end items will be compared. They are also subjected to a physical Configuration Audit. This audit includes verification of fabrication processes, on-line production testing, assembly processing as well as the usual check to standards and specifications.

Following the physical audits, the contractor must ensure that all changes in parts and material result in an "equivilant or better than" policy for replacement.[19] The contractor is responsible for ensuring that this policy is maintained with his vendors as well.

Waivers to the above process and actions may be granted to contractors for production items which do not meet specified requirements but are never-the-less considered to be suitable for use. These waivers, are classified as minor, major and critical. The definitions of waivers is further described in MIL-STD-109.

J. Funding

Sonobuoys are sensors and therefore are an integral portion of a weapon system. They are not utilized as a weapon itself and cannot by themselves inflict damage. Historically however, they have been classified as ordnance and remain so classified today. The funding of the acquisition of sonobuoys therefore does not follow the normal cycle, and sonobuoys are not funded out of accounts associated with the procurement of weapons systems. Rather, sonobuoys are considered as an expendible line item in the appropriations catagory of Other Procurement, Navy (OPN).[20] A severe limitation to this classification of sonobuoy procurement funds is the one-year limit for obligation, whereby funds appropriated for any one fiscal year must in fact be obligated during that year. This one-year cycle has been criticized as limiting the monies a contractor will spend on plant modernization and technology improvements and therefore does not enhance the reduction of unit costs. The other side of this argument however, notes the large amount of visible competition among sonobuoy manufacturers. The obvious advantage of the OPN classification lies in the relative ease of obtaining funding authorization from in-service sources instead of vieing for procurement dollars. And in support of the "other procurement" classification it must be stressed that, while technically not an ordnance item, it is used as a support item in a manner such as fuel and ammunition and should be classified as an operating expense vice a weapon system procurement.

SECTION IV

TEST AND EVALUATION

A. Background

In the 1940's, all production design approval and sonobuoy acceptance testing was conducted under the cognizance of the Naval Air Development Center (NADC), Johnsville, Penna. During this period, laboratory tests were performed by NADC and air drop tests were conducted by Naval personnel at the Naval Air Test Center, Patuxent River, Md. Bench testing of the production units normally occured at the factory, by contractor personnel who were monitored by government inspectors. Testing during this period was rather archaic from an operational sense. No specific Acceptance Quality Level (AQL), as defined by MIL-STD-105, were then employed nor did any lot rejections occur; rather the entire production line would stop, for the government would stop all deliveries when the number of defects became too large.[21] The drop tests were conducted in a water depth of only 10 feet and without the use of a reliable signal source which precluded all sonic analysis. This testing would point out only the most obvious malfunctions, such as total destruction caused by water impact or catastrophic failures. Critical failures such as improper operation of the battery or hydrophone and improper acoustic response were not detected, since facilities were not yet available for testing these areas.

As the technology improvements of the sonobuoys and their associated processors began to accelerate during the 1950's, so too did the testing requirements and techniques. Sonobuoy specifications were revised to include testing for quality assurance. An AQL was established (10.0 for major defects, and 15.0 for minor defects) as was sample size, lot size and failure classification.[22] No significant changes occured however, in the test facilities or proceedures.

In the early 1960's some rather broad improvements in this field were made. A major portion of the production responsibilities for sonobuoys was transferred to the Naval Avionics Facility, Indianapolis, Indiana in 1959-1960, and later to the Naval Ammunition Support Center,

Crane, Indiana. Additionally, in 1960, the Sonobuoy Test Facility, Pemaquid, Maine was established, which greatly expanded the testing facilities and caused flight testing of these items to become a dynamic force in controlling reliability and production lot acceptance. During this period the AQL was sequentially reduced to 6.5 and 4.0 for field testing, and to 1.5 for in-plant tests.[23]

Because of the rapid build up of sonobuoy production caused by the Berlin crisis and later the Cuban blockade, these field AQL restrictions were temporarily loosened to 6.5. (They are now back to 4.0.)[24] Also during the 1960's an additional sonobuoy field testing facility was established at St. Croix, in the Virgin Islands, and additional responsibilities were transferred to Crane. These responsibilities now included preproduction and production support, production specification maintenance, and sonobuoy test facility technical cognizance. Additionally, a research ship has been equipped to assist in testing. The combination of the shallow/cold water enviornment of Maine and the deep/warm water of the Virgin Islands are augmented by the mobile research ship for testing in actual operating enviornments such as the North and mid-Atlantic as well as the Mediterranean.

This evolution of quality assurance testing has had significant effects on the quality of units provided to the fleet, for it motivates manufacturers to produce a higher quality product and it permits the Navy to accept (and pay for) only those production quantities that have sucessfully proven acceptable by both bench and field testing, under operational conditions.

B. Preproduction Testing

Under present conditions, before a contractor submits any equipment for test, detailed testing procedures must be approved by Crane to determine equipment compliance with requirements and with specifications. These tests, which eventually lead to design approval are considered preproduction tests and are subdivided into contractor demonstration tests and service approval tests (both laboratory and aircraft drop tests).

The contractor demonstration tests are performed under supervision

of Crane personnel. A total of 50 units are submitted by the manufacturer for service acceptance tests in increments of 10, 15, and 25 units. The initial 10 units are subjected to extensive laboratory testing which includes enviornmental testing (shock, vibration, humidity etc.). The remaining two increments are tested by aircraft drop testing at the Maine and/or St. Croix facility. For service acceptance, 23 of the last 25 units must satisfactorily meet all requirements, including aircraft drop testing.[25] Naval Air Systems Command grants service approval based upon test results provided by Crane, and no changes in either design or fabrication can be made without government approval. This has caused some rather serious problems as a result of the contractors efforts to remain fully competitive by redesigning or modification. While at times seriously increasing (and at times overloading) the testing laboratories and test facilities, it has also caused a problem to fleet users in shortages of available sonobuoys. The end result however, is a well engineered, quality production item that fully meets the users requirements in both operational capability and reliability.

C. Production Testing.

Following design approval, the contractor commences production, and testing of production lots follow. These production acceptance tests are conducted in the contractors plant and at the government sonobuoy test facilities.

All inspecting and testing at the contractors plants are under the direct supervision of government inspectors and again must meet or exceed the AQL of 1.5. Each unit produced and submitted for government acceptance is inspected for material and workmanship. Further each unit is tested for proper operation, in a stabilized condition, for compliance with frequency stability and sonic performance specifications. Sampling tests are conducted on a pre-determined number of units per lot. The units are randomly selected from lots that have successfully completed the individual inspection and tests. These sample units are then subjected to extensive environmental and electronic testing. A minimum AQL of 1.5 must again be met.

The final testing of production lot sonobuoys is accomplished by aircraft dropping of smaller quantities (predetermined by contract specification) of production units that have successfully passed both the contractors individual testing and sampling tests. The normal sample size is 32 units per lot of 800. These tests are conducted by an independant firm, using government owned but contractor operated aircraft. An AQL of 4.0 permits successful lot acceptance. Entire lots can be reworked by the contractor and resubmitted for testing, however, if two successive lots are rejected, then the AQL is reduced to 3.C, until a successful test is obtained when it is returned to 4.0. Any lot that has failed aircraft drop testing twice, may not be resubmitted without specific approval of the Naval Air Systems Command.[26]

D. Feedback And Recovered Costs.

Because most failed sonobuoys are immediately recovered and examined, there is current feedback to the contractor for fault correction. This eliminates a massive factory recall or the permeation of faulty units throughout the inventory. Although approximately 10,000 of the 300,000 sonobuoys produced annually are air drop tested, a considerable cost savings is experienced because approximately two thirds of the recovered sonobuoys are returned to the respective manufacturers for rework, at a small fraction of the cost of new units. Thus, although nearly three percent of the units produced are tested, only one percent are totally destroyed; the remaining 99 percent eventually reach the fleet users.[27]

The extensive testing and stringent acceptance requirements for both preproduction and production sonobuoys has significantly increased the quality of the product delivered to the fleet. While some may argue that the total testing effort is too demanding of resources, it has been shown that it does in fact guarantee an increase in the reliability of production sonobuoys. This increase in fleet reliability has occured despite the quantitative increase in technical sophistication. And while the cost of sonobuoy testing can be quantitatively determined, the value of increased reliability cannot. The lost opportunity of submarine

detection in peacetime may result in only a minor intelligence gap and the loss of training, while missing the same opportunity in wartime could be a catastrophe.

SECTION V

CONCLUSIONS

Until such times that the designers and engineers produce a different method of finding submarines, either acoustic or non-acoustic, the aircraft, utilizing expendable sonobuoys, will continue as the mainstay of the Navy's ASW force. And as technology increases so will cost; so that future expenditures in this area of procurement will continue to increase.

An extensive period of government and industry cooperation and education in this area has resulted in a rapid growth in technology with an accompanying increase in operational reliability while reducing the relative cost of each unit. Perhaps the majority of benefits have already been obtained, but continued efforts should be stressed, particularly in the area of test and evaluation.

Due to the relatively short duration of this study as well as the nature of the underlying objectives behind it, some areas of future investigation have become apparent. In some cases the areas in question are not problems at all, but rather areas where my investigation was either incomplete or non existant. Others perhaps are bone fide problem areas and warrant further research. No priority had been established to this listing and none should be inferred.

A. Operational Requirement.

In addition to the performance functions required of the various sonobuoys, which are normally delineated by the various Navy laboratories and testing facilities involved in new acoustic processor acquisition, the most critical parameter to the fleet user is reliability. It has been suggested that sonobuoy reliability requirements have been dictated by the system reliability of individual aircraft processors. While there is a definite correlation between processor and sonobuoy reliability, I contend that the greatest driver of individual sonobuoy reliability should be the tactical application. The tacticians should specify exactly what reliability numbers are required, based solely upon operational necessity.

This should not merely be a "wish list" but based upon an in depth study of aircraft and system design, threat parameters, environments and tactical scenarios. This information should then be utilized to further investigate cost and value engineering feasibility studies to determine reliability specifications.

B. Failure Data.

To adequately determine reliability requirements it is mandatory that accurate and meaningful failure data be provided from the fleet users to those managers involved with planning and acquisition. At present the Naval Air Development Center is tasked with the gathering and analysis of all fleet sonobuoy information.[28] The final output reliability and failure data is however, only as valid as the fleet input data. To a flight crew already swamped with administrative reporting, the correctness and completeness of unverifiable sonobuoy failure information is currently not a critical issue. Reporting requirements should be reviewed, to simplify this requirement while attempting to increase the accuracy of the data gathered. Frequent visits by NADC personnel to fleet units and training squadrons, to effect education and to improve basic communication should be encouraged. Visits to fleet staffs are nice but staffs don't fly. A dialog with the flight crews is considered essential.

C. Sonobuoy Storage And Handling.

Because the sonobuoy itself is a one-time-use, expendable item, its life cycle is relatively simple. Following the final testing, and prior to aircraft launch, the entire life cycle consists of packaging, loading, storage and handling. The area of packaging has been thoroughly investigated and continued improvements are being made. Likewise, storage has recently become the area of interest. Some sites have a centralized warehouse where sonobuoys are stored under ideal climatic conditions of constant temperature and humidity. Other sites however, have them stored in open hangar decks and on make shift carts which constantly expose them to the elements. Loading and unloading from aircraft is perhaps the most damaging evolution in a sonobuoy's life cycle, and this is the area that remains essentially unchanged since World War II (with the exception of

the P-3C and S-3 aircraft which utilize self contained storage and launching containers). They are still carried by hand, up and down ladders, across pitching flight decks and are permitted to bounce on the back of flat bed trucks. If they survive this ordeal, they are permitted to remain on board these aircraft for periods in excess of their designed shelf life, in an open environment. When the buoy subsequently fails, the operator asks why don't "they" buy sonobuoys that work. In fact we should ask, why haven't "we" bought him some adequate handling and storage devices.

D. Mobilization Base Requirements.

The ability to have available in sufficient quantities, sonobuoys of the correct type, prior to the commencement of hostilities, is an absolute necessity if the requirement to find and destroy submarines during hostilities is real. You don't simply fly out to sea and kill submarines anymore. Rather you fly to the general area, which quite often is predicted o previous aircraft search information. The period immediately prior to hostilities, which could consume extremely large quantities of assets, may in fact be our only warnin that hostilities are near. The actual close area tracking of an evasive submarine consumes far more sonobuoys than are required to attack. Additionally the immediate useage rate of b oys, during any conflict, will probably exceed the steady state due to the minimum amount of accurate intelligence and quantity of targets. The numbers of sonobuoys specified as war reserve and the numbers of companies (and their maximum sustained production output) with their associated start up/build up times, must be accurately established and constantly maintained.

E. Sample Size And Lot Size.

A continuing statistical analysis of both sample and lot sizes should be conducted. In particular a sensitivity analysis of sample size and testing costs, as well as sample size and fleet reliability, should be periodically conducted to ensure optimumization of testing assets.

F. Failure Classification.

The testing and inspection of contractor furnished units is only as good as the testing criteria and procedures established. During a recent fleet deployment, using normal production (accepted) sonobuoys, I had the opportunity to participate in fleet supported aircraft drop tests with the research ship previously described, (under the direction of Crane personnel). Two specific discrepancies were noted. The first was the standard aircraft altitude for drop testing. While the operational flight profile varies from 200 feet to in excess of 27,000 feet, and an optimum altitude for search is in the neighborhood of 20,000 feet. The test drops, to similate operational requirements, was restricted for the most part to less then 5,000 feet. Is there a statistical difference in failure rates as a function of altitude? If not, the test parameters are sufficient. If there is a variance with altitude then the test runs should be changed. The second error in the test design noted was with failure recognition. In a significant number of test results, it was noted that neither fleet operator nor the test director, recognized a failure as viewed on the aircraft processor. (These failures were authenticated by the sophisticated equipment aboard the research ship). Given that the aircraft equipment was operating as required, (which was later verified), we must then be testing to requirements in excess of those needed for fleet operations. Since we test to contract specifications we must be asking for more than is required. Reducing specifications and test requirements to realistic operational requirements should ease the contractors problem of item acce tance, reduce testing requirements and cost, and eventually reduce the overall cost of sonobuoy procurement.

NOTES

1. Will Connelley, "Sonobuoy-Aircraft Combination Nullifies Submarines' Advantages", Sea Technology, February, 1976, p. 18

2. Ibid.

3. James Conn, "Management Aspects of Sonobuoy Reliability", Unpublished Thesis, Naval Post Graduate School, Monterey, Calif., 1974, p. 6.

4. Connelley, p. 18.

5. Ibid.

6. Conn, p. 17.

7. Ibid, p. 50

8. OPNAVINST, 5000. 42, 1 June, 1974, p. 3

9. Naval Ammunition Depot CRANE, Quality Engineering and Evaluation laboratory-Sonobuoy Program", briefing folder, 1976.

10. Navy Material Command, SAG Technical Memorandum 67-1, "Analysis of Sonobuoy Production Methods and Policies", January, 1967, p. 1.

11. Naval Air Development Center, Report Number NADC-72242-SD, "Aeronautical Requirements for Configuration Management of Sonobuoy and Sonobuoy Packaging," December, 1972.

12. SAG, Technical Memorandum 67-1, p. 5.

13. Ibid, p. 2.

14. Ibid, p. 3.

15. Armed Services Procurement Regulation (ASPR), Section III, parts 1 and 2, 1 October 1975.

16. Department of the Navy Determination and Findings, Authority to Negotiate Class of Contracts for Keeping Available New Sources of Supply in the interest of National Defense or Industrial Mobilization, CDF 74-14, 17 September 197[illegible].

17. SAG, Technical Memorandum 67-1, p. 30.

18. NADC Report Number 72242-SD.

19. Ibid., p. 8.

20. Conn, p. 21.

21. SAG, Technical Memorandum 67-1, p. 9.

22. NAD, Crane, p. 13.

23. *Ibid.*, p. 13.

24. SAG, Technical Memorandum 67-1, p. 9.

25. *Ibid.*, p. 11.

26. SAG, Technical Memorandum 67-1, p. 14.

27. Connelley, p. 19.

28. Conn, p. 17.

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